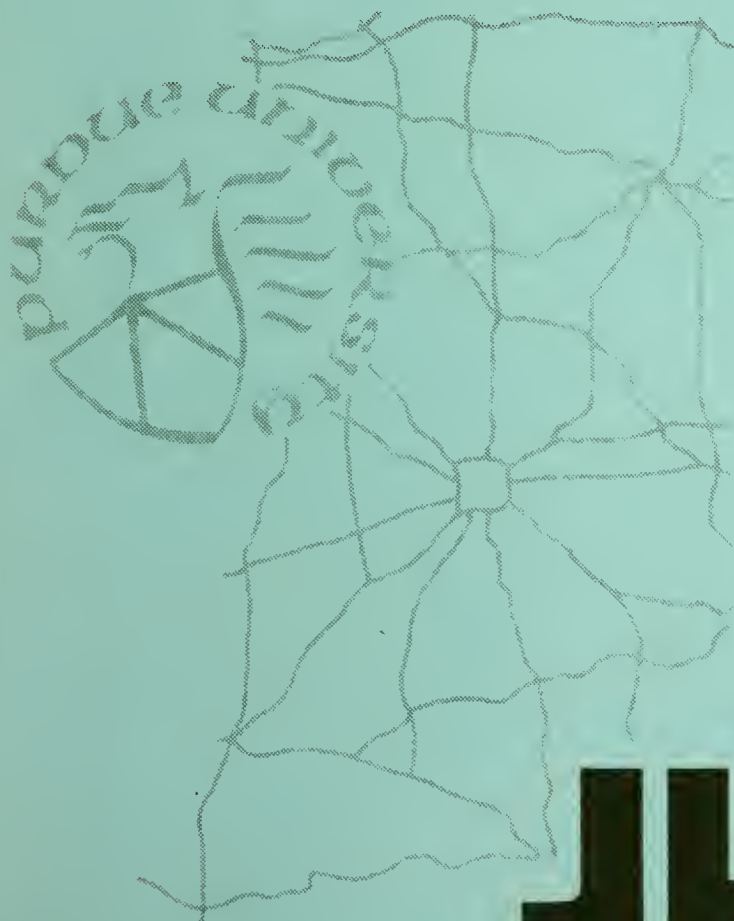


425
INTERIM — SUMMARY REPORT

MAJOR ASPECTS OF THE URBAN
TRANSPORTATION PLANNING PROCESS

MAY 1969 — NUMBER 14



WILLIAM L. GRECCO

JHRP

JOINT HIGHWAY RESEARCH PROJECT

PURDUE UNIVERSITY AND
INDIANA STATE HIGHWAY COMMISSION

Interim-Summary Report

MAJOR ASPECTS OF THE URBAN
TRANSPORTATION PLANNING PROCESS

To: Dr. J. F. McLaughlin, Director
Joint Highway Research Project

May 6, 1969

File: 3-7

From: H. L. Michael, Associate Director
Joint Highway Research Project

Project: C-36-69

Attached is an Interim-Summary Report of research activity to date on the HPR, Part I research project "Major Aspects of the Urban Transportation Planning Process." The report has been prepared by Professor William L. Grecco, principal investigator for the research project. A summary of the report was presented orally as a technical paper at the 1969 Annual Purdue Road School. It is planned to submit the full report as attached, subject to approval of all cooperating agencies, for publication in the Proceedings of the Road School.

The report briefly summarizes the activity and findings of the five research reports which have been completed, one on each of five parts of the project. These five parts are: Part I, Organization and Design of the Urban Transportation Planning Process; Part II, Trip Distribution; Part III, Traffic Assignment; Part IV, Trip Generation; and Part V, Alternative Planning Techniques for Small Urban Areas. The attached summary also contains suggestions for additional research in the topic area, at least some of which will be proposed for initiation under the project in the near future.

The attached Interim-Summary Report is submitted for approval of publication in the Proceedings of the 1969 Annual Purdue Road School, subject to similar approval of the ISHC and the BPR. It is also submitted for acceptance as partial fulfillment of the objectives of the research and as a basis for future proposals of research in this area under the HPR research project.

Respectfully submitted,

Harold L. Michael

Harold L. Michael
Associate Director

HLM:sf

Attachment

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MAJOR ASPECTS OF THE
HISTORY OF THE UNITED STATES

1882-1883

1884-1885

1886-1887

1888-1889

1890-1891

1892-1893

1894-1895

1896-1897

1898-1899

1900-1901

1902-1903

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Interim-Summary Report

MAJOR ASPECTS OF THE URBAN
TRANSPORTATION PLANNING PROCESS

by

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Project: C-36-69

File: 3-7

Prepared as Part of an Investigation

Conducted by

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Purdue University

in cooperation with the

Indiana State Highway Commission

and the

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Federal Highway Administration
Bureau of Public Roads

The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads

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Indiana State Highway Commission
or the
Bureau of Public Roads

Purdue University
Lafayette, Indiana
May 6, 1969

MAJOR ASPECTS OF THE URBAN TRANSPORTATION PLANNING PROCESS

Introduction

Population forecasters have estimated that the 1970 census when reported will show close to 75 percent of the United States population will be classified as urban. Once again one can expect that the greatest percentage change will occur in the urban fringes of central cities of population range of 25,000 to 100,000. Along with the increased population growth and dispersion comes greater transportation demands.

Urban transportation planning activity in the United States has increased significantly in the past 15 years due primarily to realization of the need to solve current problems of person and goods movements in rapidly growing areas. The immediate need for planning recommendations to guide impending development and at the same time to satisfy legislative requirements has been the prime concern of all transportation planning organizations. The result of this expediency has often been a failure to indulge in sufficient introspective examination of the various practices, methodology and techniques currently employed in planning practice.

The proposed changes in the conduct of urban transportation studies to be reported here results from research conducted by research engineers and graduate research assistants of the Joint Highway Research Project with the cooperation of the Indiana State Highway Commission and the Bureau of Public Roads of the U. S. Department of Transportation. The research had two general objectives. The first objective was to advance the technology of

transportation planning and contribute useful revisions of procedures as well as new concepts. A secondary objective was to contribute to an improved education of transportation planners who are presently in great demand. The present shortage of trained professionals will become even more acute as smaller communities perform transportation planning. The contribution of this second objective is not reported here.

Scope

The project utilized information obtained by the Indianapolis Regional Transportation and Development Study (IRTADS) and other studies in order to make detailed investigations of major aspects of the urban transportation planning process. The planning process can be structured into the following six phases: organization and administration, inventory and data collection, analysis and model development, forecasts and projections, alternative plans and systems evaluation and continuing program. The research projects summarized here were separated into parts for ease of personnel assignment and of investigation. In some cases the project (part) could not be specifically categorized into one of the above six phases because of the interrelationships under study.

The first part was to study the general organization and administration of the planning process. It was to review the present state-of-the-art of transportation planning from the study design through to the continuing phase. From this investigation, there would be information available from which

procedures might be modified especially for studies in smaller urban areas.

Part II would specifically examine the importance and characteristics of work trips and peak hour travel in defining the principle transportation corridors of an urban area. Based on the above findings, the investigation will examine the substitution of work trip surveys for the conventional origin and destination survey. The importance of work travel is enhanced by the U. S. Bureau of Census' interest in obtaining journey-to-work information in connection with the decennial census. There appears to be a possibility of obtaining sufficient detail on this travel to permit use of Census data for transportation plan updating or even the original work. Therefore, the work travel analysis of this project will be oriented to study the feasibility of such a procedure.

In Part III, a new concept in the assignment of traffic to a street network would be examined. This concept is based on the realization that the traffic assignment phase of an urban transportation study has as a main function the determination of the deficiencies of an existing network and the testing of a proposed plan as to its ability to accommodate future traffic. To achieve this, acceptable levels of service which reflect the study objectives are established for every pair of zones. Deficiencies are measures of the extent to which a network is unable to provide the assigned traffic at the desired levels of service.

The trip generation process is to be studied in Part IV. The aim of this investigation is to determine and test the

significance of accessibility as a predictive variable of trip generation rates. This will include the building of generation models (both attraction and production) which take into account the configuration of the transportation system, the level of service at which it operates, and the layout or growth pattern of the urban area.

Part V would establish a methodology for the development of alternative major thoroughfare plans for a small urban area without an origin-destination study. The purpose of this part would be as follows: 1.) to develop and define the principles, standards, and related criteria to be considered in the development of a thoroughfare system for a small urban area and in the specific location of the components of the system; 2.) to develop a simplified means of evaluating these criteria for the system and its components; and 3.) to apply the developed technique to the Lafayette, Indiana Metropolitan Area, and develop a thoroughfare plan for this area.

Summary of Findings

It would have been most desirable to report that the results of each of the five parts of the research built one upon the other to achieve a single recommendation for changes in the urban transportation planning process. This was not the case, in fact, results from some parts would preclude the application of results from another part. The findings of each part are summarized separately and where pertinent to the finding, the procedures used will be noted. Where possible

application was sought for the smaller urban areas.

General Organization and Administration

This part of the research is directed toward the development of an effective means of explaining the transportation study process to the persons appointed to the technical committees in smaller urban areas. For purposes of this part, a smaller urbanized area is defined as being in the range of 30,000 to 300,000 population.

The technical committee of a smaller urban area Study is often given the responsibility for the design and administration of the planning process. Thus, it was felt that any explanation of this process should include not only a translation of the jargon of existing technical literature, but also the results of critical reviews of Studies that already have been through at least part of the planning process. Such an approach would point out the alternative technical procedures that have proven to be both feasible and efficient; it would point out the shortcomings of those that experience has shown to be impractical; and hopefully it would reflect a time scale of the learning process that has been experienced by the expanding art of transportation planning. In light of these hypotheses, an interview questionnaire was prepared to structure an analysis of the experiences of Studies already in operation. The questionnaire included questions on the following topics:

1. What evaluations were used to develop the initial Study design;

2. What procedures were actually used and what major problems were encountered;
3. In reviewing the Study, were any of the procedures inadequate, too extensive, or otherwise unsuitable; and
4. What were the estimated and the actual time and cost allocations for the Study?

Through correspondence with BPR and the State Highway Departments, contacts were established with Studies in Colorado, Illinois, Indiana, Kentucky, Michigan, New Mexico, North Carolina, New York, Ohio, Pennsylvania, Rhode Island, and Texas. Where possible, the questionnaire was discussed during a personal interview with members of the technical committees or the Study staff. In a few cases telephone interviews were utilized, and in several cases information was provided without an interview. Interpretation of the data was greatly aided by a number of discussions with personnel from BPR's Washington, Region 9 and Colorado Division offices; from the transportation planning divisions of the Indiana State Highway Commission, the Colorado Department of Highways and the Kentucky Department of Highways; and from Vogt-Ivers and Associates and Barton-Ashman Associates, both transportation planning consultants. Where conclusions are made, they are the sole responsibility of the author. Specific findings are further classified.

Organization. The majority of the Studies were established only as a result of the 1962 Highway Act. The smaller urban areas have come to depend on the State Highway System as their

major traffic arteries. The threat of the loss of State and Federal financial aid to continue to improve these routes has been successful in getting the local agencies to agree to participate.

Initial Efforts. The initial efforts of most of the Studies have come from the State Highway Department. Generally they are in the best position to recognize the need and are the most knowledgeable on the subject of transportation planning. One caution worth noting is that in many cases local enthusiasm never does develop under this start.

Committees. The committee systems in use varied in form and responsibility. In general, the policy committee, with the exception of the State Highway Department representative, had little knowledge of transportation planning and tended to delegate almost all of their responsibilities to the technical committee members, although reserving the right to make final decisions.

As a consequence, the technical committees effectively governed the entire Study. Thus, the composition of this committee plays a very critical role in the success of the planning process. Unfortunately the shortage of persons knowledgeable in transportation planning has greatly hindered the effectiveness of the committee. Most often this had tended to cause the State Highway Department to become the predominant influence.

The third part of the committee system, that of the citizens advisory group, has been of little help to most of the Studies. This condition can best be attributed to the general inability

of the technical committee members to communicate the need and operational scheme of the planning process. The citizens, while sharing a general concern for adequate urban services, are seldom able to determine what alternative solutions are actually feasible. Thus, until their position in the planning process can be adequately integrated into the Study operation, it is virtually impossible for their efforts to be effective.

Staff. The majority of the Studies have used a consultant and/or State Highway Department dominated staff. In general, the local agencies have been asked to provide data when such an arrangement was convenient as a contributed service substitute for financial contributions. This approach has produced a number of cases of totally inadequate data. The local agencies look upon the data request as an extra assignment that only interferes with their required routine responsibilities. Thus they tend to assign unqualified personnel to the task of compiling the data.

Generally speaking, a consultant should provide a service that is not within the technical ability of his client. In the case of transportation planning this would generally be in the area of forecasting future travel demands and developing technically feasible improvement plans to adequately serve that demand. However, because of the shortage of personnel in local agencies and State Highway Departments, a number of consultants have been performing the entire planning process, including many of the routine, well-defined procedures that should not be beyond the capabilities of the local agency personnel. The result of such an approach has been a series of plans that have become unusable

or unwanted by the local agencies responsible for the commitments necessary for implementation. Thus it would appear that the extension of a consultant's services to include a source of labor may be destroying the benefits of his technical competence.

Study Design. The design of work programs for most of the Studies followed the recommended procedures of NCUT and BPR. The few exceptions were cases where consultants were given an opportunity to develop their own. Because much of the present knowledge about transportation planning has evolved as a result of the efforts of the early Studies, the accepted procedures have been subjected to many modifications. At the operations level there has been a tendency to keep them as simple as possible. This attitude results largely from a realization of the technical limitations of the operations personnel. On the other hand, BPR has been attempting to incorporate the positive results of its many research programs into the Studies and in so doing hopefully increase the accuracy of the travel demand forecast.

Costs. One of the initial intents of this part was to isolate the costs involved in performing the various phases of a Study. From such an analysis it was hoped that a typical cost breakdown could be developed as an aid to future Study designs. However, in discussing costs with the various agencies it became apparent that such information is almost impossible to obtain. There are two primary reasons for this. The costs incurred by local agencies and State Highway Departments have

not been coded with the intent of obtaining unit costs and often are coded to an administrative system that completely masks such information. Where consultants have been used, the costs, while coded properly, are a part of the private information that they use to retain their competitive position and thus are not available in a form that would make them useful.

Inventory. The evolution of transportation planning has included the collection and sifting of a multitude of data types. Some of these efforts have proven to be of little value to the planning process. However, because of the magnitude of the physical efforts required to obtain data such as land use characteristics and travel desires, many persons presently involved in Studies tend to consider the inventory phase as the major part of the planning process. This attitude appears to be reinforced by the manuals prepared by NCUT. However, the evolution of planning procedures has begun to place less emphasis on present day data other than as indications of fundamental patterns of urban activities.

Data Accuracy. The value and sensitivity of inventory data was questioned by most people involved in Studies. Outwardly there appear to be large variations in the relative accuracy of the data that are being used. Because of the lack of consistent historical records it has been almost impossible to determine the effects of these variations. Without such information, the value and corresponding accuracy requirements can be based only on the subjective interpretation of the persons using them.

Travel Data. The development of trip prediction models has not yet progressed beyond the need for some current measures of trip patterns. The personal interview continues to be the most accepted means of obtaining the required data. However, the high cost of obtaining statistically adequate data continues to encourage research into smaller sample size techniques and into alternate methods of obtaining current trip information. Procedures that appear to be inadequate for initial investigations into travel patterns may prove to be ideally suited for the continuing Study.

Land Use Data. Travel demands are intimately related to land uses. However, developing justifications of the cost required to maintain current and historical records of land use has been an extremely slow process. The sooner smaller communities adopt the data bank concept, the smaller will be the total community costs.

Travel Demand Analyses. Research has pointed out that the development of forecast models can be a more effective way of anticipating future demands, especially in a rapidly changing urban area. Practical applications in operational Studies have at least tentatively documented this concept. The short time period over which the models have been operational makes any comparison between projection and conceptual model forecasts somewhat of a subjective evaluation.

Given that forecast models do indeed provide a superior estimate of future travel demands, the problem of developing

adequate forecasting procedures is by no means solved. There have been many models proposed for the various phases of travel demand. However, few of them have been developed to the point where the technicians who are available to the smaller urban area can use them effectively. One of the main problems is the misunderstanding between model evolution and model calibration. The distinction between these two is emphasized in the manual (See Reports Issued).

Some of the problems one can expect to find in the smaller urban areas are due to the understanding of the models in these analyses. Too many times, models are computer programmed to produce numbers and these numbers are accepted and held sacred by the technicians. This belief or faith is also taken up by the designer who is already searching for a number.

Forecasts. There appears to be a tendency to spend so much time developing models that once they are operational it seems almost trivial to provide the necessary estimates of future urban growth required to obtain a forecast of travel demand.

One problem to be faced in the forecasting process is the reconciliation of the forecast estimates demanded by the traffic analyst and provided by the economist and land use analyst. There appears to be a great deal of work ahead to insure that the accuracy of the forecasts is of the same order of magnitude as that of the subsequent travel demand developed from the forecast.

An additional part of the forecast that is presently receiving only token recognition is that of financial resource

estimates. In order to realize the implementation of transportation system improvements, the financial appropriations must have some realistic basis. The role of the Federal Government in urban improvement financing has been rapidly changing over the last twenty years. Thus, many of the Studies have indicated that a financial forecast would be a waste of time unless the future sources of revenue could be defined. It appears that additional research into the financial future of urban areas should be of great concern.

System Testing. One of the main concerns in the system selection process is the establishment of standards on which to base design deficiencies. There are large variations in what constitutes an adequate transportation facility standard. The State Highway Department generally has minimum standards. These have been extended to non-Federal-aid urban arterials through the TOPICS program recently enacted by the Congress. However, the remaining urban street system is subject only to what standards the local jurisdictions may have established, thus providing a double standard to be applied to any improvement program. The problem is also due in part to the lack of adequate procedural outlines into system selection. Without such guidelines, the Studies with their inexperienced staffs have not been able to develop adequate methods.

Continuing Study. The 1962 Highway Act was a decisive step in the transportation planning process. It forced a commitment to major planning efforts. One point of that Act that is only

beginning to be felt is the emphasis on the continuing efforts required to maintain a plan that is responsive to change. Almost without exception the Studies have ignored that part of the Act in their efforts to get at least an initial plan. As this is becoming more of a reality, they are beginning to establish the basis for a continuing program.

As noted earlier in the discussion, the development of adequate procedures for the initial plan formulation is no assurance that the continuing phase requirements have been satisfied. In fact there are a number of preliminary indications that the initial phase procedures are entirely too costly to be used in updating previously determined data.

Manual. The contribution of this research will come when the information manual developed under this part is widely distributed to the technical committees in the smaller urban areas.

Travel Patterns from Work Trips

The purpose of this research was to determine the feasibility of using only work trips, and alternatively, only peak hour trips to work to reproduce the demand on a highway system, exhibited by trips for all purposes and those occurring during the entire day. The hypothesis thus proposed implies that the system capacity demanded by work travel during the peak periods is available for and is indeed used by trips for non-work purposes, which occur during non-peak periods. Therefore, a highway system which serves work travel will properly serve

other travel as well. This situation is not perfectly true, but the research proposes its applicability on the major street and highway system which is generally included in an urban transportation study.

The importance of the work and peak hour portions of total urban travel is underscored by the extent to which they have been subjected to previous analyses. Their regularity and stability are characteristics important in consideration of predictive parameters. It would seem that they might well serve as sufficient singular bases for prediction of a highway system to serve all urban travel. Indeed, this relationship has previously been suspected or accepted by some and even employed occasionally. But the literature is devoid of what the authors consider adequate quantitative substantiation of the relationship.

The application of the thesis proposed here concerns elimination of the traditional home-interview O-D survey in favor of a travel pattern survey at the destination (employment) place. In this regard it is important to emphasize that the approach taken in this research does not utilize such a technique. Rather, its purpose was to establish a firm basis for future development of an employment place survey procedure by demonstrating that work travel is indeed an adequate representation of total urban travel on the major highway system. The extension of feasibility to the peak hour would provide a direct hourly volume for design purposes.

Basic Effects. The procedures employed to test the proposed hypotheses fell into two distinct phases. The first was directed toward establishing a basis for consideration of the second. The second phase was directly concerned with testing the principal hypotheses regarding work and peak hour travel.

Phase one undertook examination of the hypothesis that the several factors of trip purpose, mode of travel, and time of trip do significantly influence the character of person movement in an urban area. The objective was to obtain a quantitative definition, in probabilistic terms, of that interrelationship which most practitioners have come to accept in a qualitative sense. The variables chosen for examination were travel volume and length of trip.

The assumptions required for use of the analysis of variance (ANOVA) were considered sufficiently satisfied. All main effects and interactions were significant ($\alpha = 0.01$). The high significance of the main effects had been expected. It implied that the volume and length of trips differed significantly with the purpose of trip, the mode of travel, and the time of observation. The significance of the interactions was not anticipated. It implied, for example, that the relationships between volume or trip length and the single factors (e.g., purpose) were inconsistent if any other factor was not held constant. The results of this analysis emphasized that the factors examined in regard to travel pattern development were worthy of further consideration. They also indicated that further analyses would have to account for the interactions.

Specific Effects. This analysis involved testing the principal hypotheses, concerned with the use of work and peak hour trips to represent the important total daily travel. The objective of the analysis was to determine whether trips of a single purpose or a particular time period could be expected to define the transportation system used by all travel. Travel volume on individual links of the highway network was the decision variable selected. Reflection on the objective of the research pointed up the necessity of retaining the all-purpose loading as the control condition, against which the hypothesized revisions would be tested.

The tests on the freeway links indicated significant results due to the main effects of time, purpose and mode. No effect on the links relative importance was noted due to interaction. It can be concluded that link relative importance does vary between the peak and non-peak periods, due to change in consideration of the work or the non-work purpose, and due to travel mode. The implications are that, for freeways, separate regression models describing peak and non-peak traffic would yield better results than a single model.

Regressions. The multiple linear regression analyses examined the three separate street classes and several combinations of these. The examination of several street groups was undertaken in order to determine the changes in predictivity for various single classes and combinations within the total street system. Within each street group several mode-time combinations for the variables were used. In four

of these cases, the mode-time condition was the same for the dependent and independent variables. In the remaining cases, the mode-time condition of the independent variable represented a more practicable survey procedure than did the mode-time combination of the predicted variable. All dependent variables represented mode-time combinations useful in planning and design.

All independent (single purpose) variables were available for selection in the free entry regressions. The entry order and parameters of fit were affected by the individual street classes or combination of street classes considered. The entry order for a given dependent variable for the separate classes was somewhat erratic, but for the combinations it was fairly uniform. The home-based work trip that was consistent with the mode-time condition of the dependent variable was the first variable to enter in all regressions. Predictions of total day volume usually chose shopping trips second, followed by the respective non-home-based work group. The reverse was true for predicting peak hour trips. It is apparent that shopping travel is more important in total day than in peak hour travel. The fourth entry was generally too erratic to permit valid conclusions.

The regressions involving dependent and independent variables of different mode-time groups exhibited less precision than the homogeneous cases. The differences were slight in all cases, however, and probably are easily rationalized in light of survey cost savings. The general trends of all

parameters are similar to those observed in the homogeneous cases. The important fact is that the generally excellent predictivity is exhibited in those situations which imply more feasible survey procedures.

The implications of these results are important to the selection of survey procedures. Based on the findings of the increase in R^2 and the decrease in standard error of estimate and coefficient of variation, the order of survey complexity follows directly. The same progression follows for all mode and time groups. A vehicle trip survey of home-based work trips requires employer records of those employees driving to work. A home-based work person trip survey requires tabulation of all employee records and a tabulation regarding mode. An all work trip (home- and non-home-based) survey requires interview of drivers or all employees, depending on the mode of interest. Extension to include shopping trips requires, in addition, a license plate survey at shopping districts. Decisions on the form of any revised survey procedure are best made according to costs and feasibility. This research has provided the study director with alternative procedures for replacing the costly home-interview survey. It must be his decision, in light of the community conditions, to select a feasible alternative which will provide valid travel patterns at the least possible cost.

Application. The analyses discussed previously were directed at eliminating the need for a home-interview survey to establish the patterns of urban travel. The following discussion

will suggest how the techniques proposed would be implemented in the urban transportation planning process.

The major revisions concern the home-interview survey. If an all-purpose, peak hour analysis has been selected, the only revision will be elimination from the home-interview data of all but peak hour trips. Use of a work trip oriented approach would imply complete elimination of the home-interview. Further decisions on procedure rest on the extent of analysis desired. A home-based work oriented analysis requires only examination of employer records. The basic information to be obtained is the address of the employee's residence. Additional information regarding salary and family characteristics might also be obtained to refine the analysis and do special studies, providing necessary permission can be obtained. If the analysis is to consider trips during the entire day, all employees would be tabulated. A peak hour orientation would require definition of the shift or reporting (or leaving) time of the workers, selecting only those which would necessarily be traveling during the peak hour chosen. Use of vehicle trips only, or a need to determine mode for all travelers would employ a procedure such as having employees place their time cards in different bins, according to their travel mode. An alternative approach would involve mode tabulation for each worker by either supervisors or survey personnel.

Decision to include all work trips in the analysis would require a more involved survey. In essence, each worker would have to be interviewed in some manner. The interviews could

be conducted one at a time by either supervisors or study staff personnel. Alternatively the workers could be surveyed by use of a questionnaire. Direction in completion of the questionnaire could be given either locally by monitors or to the entire work force simultaneously by means of a public address system. The basic data sought would be the address of the origin and destination of all trips made to or from the employment place. A "contact" survey could also obtain such information as mode, time, and routing of the work trip as well as attitudes regarding work travel. Use of a questionnaire is less satisfactory than an interview, but it is also less expensive and time consuming. The balance in difficulty and cost would have to be weighed against utility. Further extension of the proposed procedures to include shopping travel would involve tabulation of arrivals at major shopping areas. Use of only home-based shopping trips by vehicles would merely require tabulation of license plates. This could include the usual parking study as an adjunct. Including all home-based shopping person trips would require tabulation of the number of persons arriving in each vehicle. Shopping trips by transit would be prohibitively difficult to survey.

Depending on the survey procedure and approach selected, expansion of the survey results might be necessary in order to obtain true traffic volumes. Alternatively the expansion could be based on figures from micro-sample home-interviews or questionnaires sent home with workers interviewed in the principal survey. The regression coefficients developed in the previous

analysis may provide at least a good first approximation to expansion factors. The results of the survey or the expansion, as applicable, would be assigned to the street network in the same manner as usual, followed by the appropriate capacity restraint iterations. Development of the distribution model would use work and residential trip ends developed from the survey in the same manner as usually employed. The model results would be expanded by the traffic volume factors discussed previously in order to perform screenline and cordon checks where appropriate.

Development of the future travel potential would, of course, be based on the economic base and population studies. These would be combined with the existing land use information to determine the future pattern of employment generating activities. After allocating employment and residential activities, the work trips would be distributed as before. The traffic expansion factors, modified to account for changes over time, would be used to obtain total volumes. Care would have to be given to incorporating where necessary changes in ratios implicitly assumed constant in this analysis, such as work travel as a proportion of total area travel.

The work described here is merely a demonstration of one feasible extension of the reported research. It is not implied that the results of this research do more than indicate the possible feasibility of revised survey procedures.

Traffic Assignment

The purpose of this research investigation was to develop a rational concept for the evaluation of transportation systems.

The concept was designed to permit the analysis of any transportation system by quantifying the degree to which its facilities satisfy the study objectives and the travel desires of the community. This new concept is identified as the Simplified Proportional Assignment Technique or simply SPAT. It was based on the premise that the community objectives as related to transportation are the attainment of particular levels of service between origin-destination combinations within the study area. These levels of service may differ from one community to another and may vary over the years for the same community. Proper service levels are selected to reflect the desires of the people for a transportation system which must be restricted by financial and technological limitations.

The establishment of the levels of service desirable of a selected system for a particular stage in the community growth pattern determines the framework within which an acceptable plan is to be developed. Only those plans that meet these levels of service are considered in the decision-making process. The adequacy of an existing system in meeting the desired levels of service is first investigated. For every origin-destination combination, all routes providing movement between the terminals of a trip at pre-set service levels are determined. Trip interchanges are then assigned to these routes on a proportional basis in accordance with their relative attractiveness for the particular travel interchanges. The plan used in the assignment technique may include either an existing or a proposed system of transportation.

The application of the above assignment model may result in one or more of three possible outcomes. First, no route may exist between an origin and a destination that can accommodate traffic at the desired level of service. This situation is defined as a zonal deficiency, and system improvements must be planned for these unassigned travel interchanges. Secondly, some links may be assigned more traffic than they are able to carry at the desired levels of service. In this case, improvements are needed on or in the vicinity of these links to carry the excess traffic. Thirdly, the existing or proposed system may be able to carry the assigned volumes and provide the desired levels of service with no deficiencies.

The proposed procedure for proportioning traffic among several acceptable routes includes the following sequence of operations.

1. An attractiveness index is calculated for each acceptable route according to the following equation.

$$F_1 = \frac{1}{T_1^a} \times \frac{1}{D_1^b} \times \frac{1}{N_1^c}$$

where F_1 = attractiveness index of route "1".

T_1 = travel time on route "1".

D_1 = total distance on route "1".

N_1 = number of nodes on route "1".

a = exponent of travel time.

b = exponent of total distance.

c = exponent of the number of nodes.

2. The trips to be assigned to each route are obtained from the following relationship.

$$L_i = L \times \frac{F_i}{F_1 + F_2 + \dots + F_n}$$

where L_i = trips assigned to route "i".

L = total distributed trips to be assigned to the alternate routes.

n = number of acceptable routes.

The values for the exponents a , b and c are dependent on the trip purposes. A sensitivity analysis was performed on the proportionality factor for varying values of the exponents of travel time, total distance and number of nodes. The resulting attractiveness indices varied only by 5 to 10 percent for various combinations of exponent values ranging from the square root to the second power.

Further research in the area of driver behavior is needed to quantify these variables. For the purpose of demonstrating the application of the new concept, the value of 1.0 was assigned to these three variables in the succeeding applications of the Simplified Proportional Assignment Technique.

The following operations comprise the main features of the technique.

1. The study objectives as related to transportation in a community are expressed as the attainment of specific levels of service between pairs of urban zones within the study area.

2. All routes that can move traffic at these prescribed levels of service are determined, and trip interchanges are

assigned to these routes on a proportional basis. The evaluation procedure may result in the detection of zonal and/or link deficiencies. A zonal deficiency represents the absence of a route that can move traffic at the established service level, and a link deficiency occurs when the desirability to use a street segment exceeds the ability of this segment to provide a specified quality of traffic flow.

3. This procedure is applicable to either an existing or a proposed transportation system. The adequacy of a proposed plan is confirmed when the transportation facilities are able to accommodate a given set of trip interchanges at the desired levels of operation without the presence of either zonal or link deficiencies.

The acceptable routes in SPAT are obtained by specifying an upper limit on the percentage of route overlap between two or more corridors of travel. A 7-percent overlap at either end of the routings provided the best corridor representation of the acceptable routes in the analysis of the selected trip interchanges in Indianapolis, Indiana. A further limitation was placed on the number of acceptable paths for more efficient use of the proposed technique. The travel time and total distance for all acceptable routes was not permitted to exceed 1.75 of the corresponding values on the minimum-time path.

The Simplified Proportional Assignment Technique is a practical and reliable procedure for system evaluation. The use of the technique in urban transportation studies permits

the quantitative determination of the adequacies of proposed plans. Because the use of SPAT to evaluate a transportation plan is achieved by direct reference to the study objectives, differences among communities in desires and resource limitations are incorporated in the procedure.

Development of a computer program for the application of the Simplified Proportional Assignment Technique was included in this investigation. The program was applied to two cities to quantify some of the variables of the concept and to demonstrate the use of the technique in urban transportation studies.

Trip Generation Process

The purpose of this research was to study the trip generation process, with the specific aim of investigating the feedback from the transportation system on the rate of trip making. Conceptually, there is no strong basis for assuming that trip making is independent of the transportation system. On the contrary, it seems that trips produced by, or attracted to a zone should be a function of the relative accessibility of the zone to different land uses, in addition to the characteristics of the zone itself.

Trip making is a product of the desire for human interaction. Within present day technology, way-of-life, and the requirement of compatible land uses, different daily activities have to be performed at different locales. Basically, the rate of trip making is a function of two categories of variables. One category represents variables which tend to increase the

potential of trip making; the other constitutes the restrictive forces. Variables such as the availability of the vehicle to the residents of a zone, and the percent participation of the residents in the labor force; or the number employed in a zone, and the amount of floor area of different land uses in it are examples of the first category of variables. They measure respectively the potential of trip production or trip attraction. The penalties incurred by travel measured in cost, travel time, or travel distance represent the variable which belong to the second category, the restrictive forces.

This study utilized data obtained from the surveys for the Indianapolis Regional Transportation and Development Study (IRTADS). Multiple linear regression predictive models of person-trip productions and attractions, by purpose, were developed. The developed models differ from the traditional trip generation models. The independent variables were not restricted to socio-economic and land use measures of the zones, but included also measures of the relative accessibility of the zone to different activities and land uses.

The locational aspects that affect trip generation were also investigated. It was hypothesized that central locations in the study area, generally, afford greater accessibility; and the convergence of the street network on the city center favors the core location. The zones of the study area were stratified into two groups: a central and a noncentral. This stratification was entered as an independent dummy-variable in the trip generation analysis.

A comparison of the forecast trip generation by the suggested approach with the forecast by the traditional approach was conducted.

The following methodology was used in this investigation. Trip generation models which take into account accessibility variables were developed from data from an operational transportation study. These models were then compared with the conventional models developed as part of the transportation study. Both sets of models were used to forecast 1985 trip generation. The two sets of forecasts were compared by testing for any significant differences, on a zone-by-zone basis, between the two forecasts.

Models that take into consideration the stratification of the zones of the study area into central and noncentral sets were also developed. This stratification was investigated for the models developed by the transportation study and those developed by this investigation. Also investigated were the ranges of the independent variables for the survey year and the forecast year.

Since the main purpose of this investigation was to compare the sets of developed models with accessibility variables and zones stratified into central and noncentral sets to models developed in the traditional approach by an operational transportation study, care was taken to keep any factors that might disturb the comparison out of the developed models; so that the comparisons would be most valid.

The decision to develop multiple linear regression models of trip generation using data summarized by zone was mainly in the interest of keeping the results of this investigation comparable to those from an operational transportation study.

This investigation was limited to six trip production purposes, five trip attraction purposes, and two control totals (one for all productions and one for all attractions). Trip generation equations were developed for the following dependent variables:

1. Home-based work person-trip productions.
2. Home-based shop person-trip productions.
3. Home-based school person-trip productions.
4. Home-based other person-trip productions.
5. Non home-based work-oriented person-trip productions.
6. Non home-based non work-oriented person-trip productions.
7. Total person-trip productions.
8. Home-based work person-trip attractions.
9. Home-based shop person-trip attractions.
10. Home-based other person-trip attractions.
11. Non home-based work-oriented person-trip attractions.
12. Non home-based non work-oriented person-trip attractions.
13. Total person-trip attractions.

It was not possible to develop an equation for home-based school person-trip attractions because the key independent variable, school enrollment, was not available.

The socio-economic and land use variables, that were available and used by this study as independent variables in developing

multiple linear regression models of trip generation, were:

- | | |
|----------------------------|-----------------------------------|
| 1. Total employment. | 6. Dwelling units. |
| 2. Retail employment. | 7. Labor force. |
| 3. Service employment. | 8. Population. |
| 4. Retail floor area. | 9. Cars. |
| 5. Educational floor area. | 10. Single family dwelling units. |

Criteria were established for stratification of the study area into central and noncentral areas. It was assumed that the central and noncentral areas might reflect two different trip generation patterns due to the shape of the study area, its historical quasi-annular urban growth, and the configuration of the transportation system. This differentiation of the central and noncentral areas was categorical instead of numerical, and could best be treated through stratification.

The following criteria were established as a first approximation to delimiting the central area:

1. The delimitation was to be performed at the district level.
2. The central area would, probably, include all of sector zero and some of the qualifying surrounding districts.
3. The districts of the central area should all be contiguous and connected.
4. A district which would qualify must satisfy at least two of the three following criteria:

- a. In the lower quartile of all the districts of the study area in percentage of urban land in residential use.
- b. In the upper quartile of all the districts of the study area in the percentage of land in urban use.
- c. In the upper quartile of all districts of the study area in the ratio of hundreds of square feet of uses usually seeking central location to acres of urban land in each district.

The results of this delimitation are shown on Figure 1.

Basically, four sets of models were developed. Two were without any relative accessibility variables among their independent variables; one of those two was the set developed by the traditional procedures for IRTADS (Set W-U); the second set contained a dummy-variable which defined the zone location and/or some of the interaction of the dummy-variable with the other independent variables in the equation (Set W-S). Of the remaining two sets, each had relative accessibility variables and, in addition, one was calibrated with stratified data (Sets A-U and A-S respectively).

Model comparisons included:

1. improvements achieved by introducing relative accessibility variables to the basic IRTADS models, that is models of set A-U versus models of set W-U;
2. improvements achieved by calibrating the models with data stratified according to the zone location over the

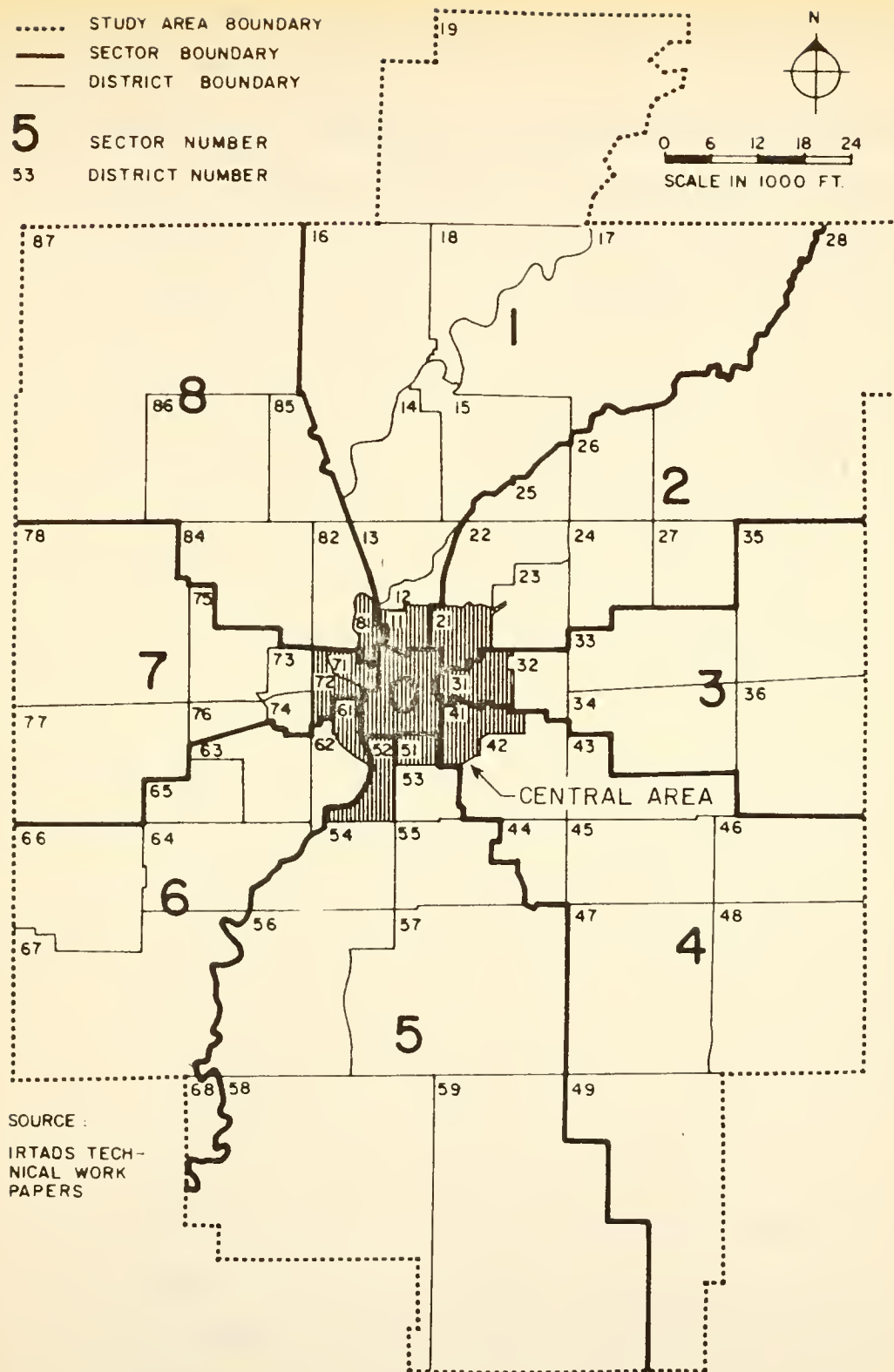


FIGURE I — STUDY AREA STRATIFICATION :
 CENTRAL AND NON CENTRAL

basic IRTADS models, that is models of set W-S versus models of set W-U;

3. improvements achieved by calibrating the models containing relative accessibility variables with data stratified by location over similar models calibrated with unstratified data, that is models of set A-S versus models of set A-U; and
4. improvements achieved by introducing both relative accessibility variables and calibrating the model with stratified data over the basic IRTADS models, that is models of set A-S versus models of set W-U.

Based on the preceding analyses, the following conclusions can be drawn.

1. Among all of the relative accessibility variables considered, the following variables were included in the trip generation models which were developed:
 - a. accessibility to employment in conjunction with home-based work person-trip productions and non home-based work-oriented person-trip attractions
 - b. accessibility to labor force in conjunction with home-based work person-trip attractions
 - c. accessibility to single family dwellings in conjunction with home-based shop person-trip attractions and home-based other person-trip attractions

- d. accessibility to educational floor area in conjunction with home-based school productions, and non home-based non work-oriented person-trip attractions.

The preceding accessibilities were each calculated with the friction factor corresponding to the same trip purpose as the modal under consideration.

2. Relative accessibility variables in trip generation models improved the statistical strength of models of person-trip attractions more than that of models of person-trip productions. Competition is a more important locational consideration for high-attraction zones which indicates their need for greater accessibility.
3. Calibrating trip generation models with data stratified according to the location of the zone in the central or noncentral areas always improved the statistical strength of the models whether the models had accessibility variables or not. Models of home-based person-trip attractions were least improved by stratification, indicating substantially similar attracting characteristics for work trips by zones in the central and noncentral areas.
4. In general, the statistical strength of the models was better achieved by stratification alone than by including relative accessibility variables only.

5. Models of home-based work person-trip productions or attractions were improved least by including relative accessibility variables and/or stratification. This is expected because work trips are inelastic to trip length, due to their regularity and essentiality.

The four sets of developed models were solved with the 1985 forecasted values of the independent variables. The forecasts were analyzed to identify comparative forecasting trends of the different models. The following conclusions were drawn.

6. It was observed that stratified models consistently forecasted more trip productions and attractions for zones of the noncentral area and less for zones of the central area than models without stratification. Stratified models are thus sensitive to the situation of equilibrium and saturation being reached in the central area, and also, the faster rate of traffic growth in the noncentral area.
7. 1985 forecasts of person-trip productions and attractions by models with relative accessibility variables and that were calibrated with stratified data were significantly different than forecasts by basic IRTADS models. There was not a detectable trend as to the sign of the mean difference between zones of the central and noncentral areas. Further analysis indicated that stratified models with relative accessibility variables forecasted more productions and attractions than forecasts by basic

IRTADS models, in general, for zones located in the vicinity and along corridors defined by the major thoroughfares of the study area. This reflects a possible locational aspect of trip generation in addition to the central-noncentral stratification. See Figure 2.

8. From the study of the range of the values of the forecasted socio-economic variables as compared to their range in the base year, it was concluded that the anticipated growth in the outer parts of the study area should be taken into consideration at the outset of the study namely, in defining the zones. Care should be taken to limit the size of these outlying zones to keep from having forecasted values of the socio-economic variables that are outside the range of the base year values.

The trip generation models proposed by this research are function of the status of the transportation system. In an operational transportation study future forecasts of trip generation would then be affected by the nature of the proposed transportation network. And since the proposed network should be designed to serve future trip generation; therefore, an iterative process should be followed. It would be terminated when an equilibrium between the future supply of transportation (proposed plan) and the demand for transportation (travel forecast) is reached. This iterative process is illustrated in Figure 3.

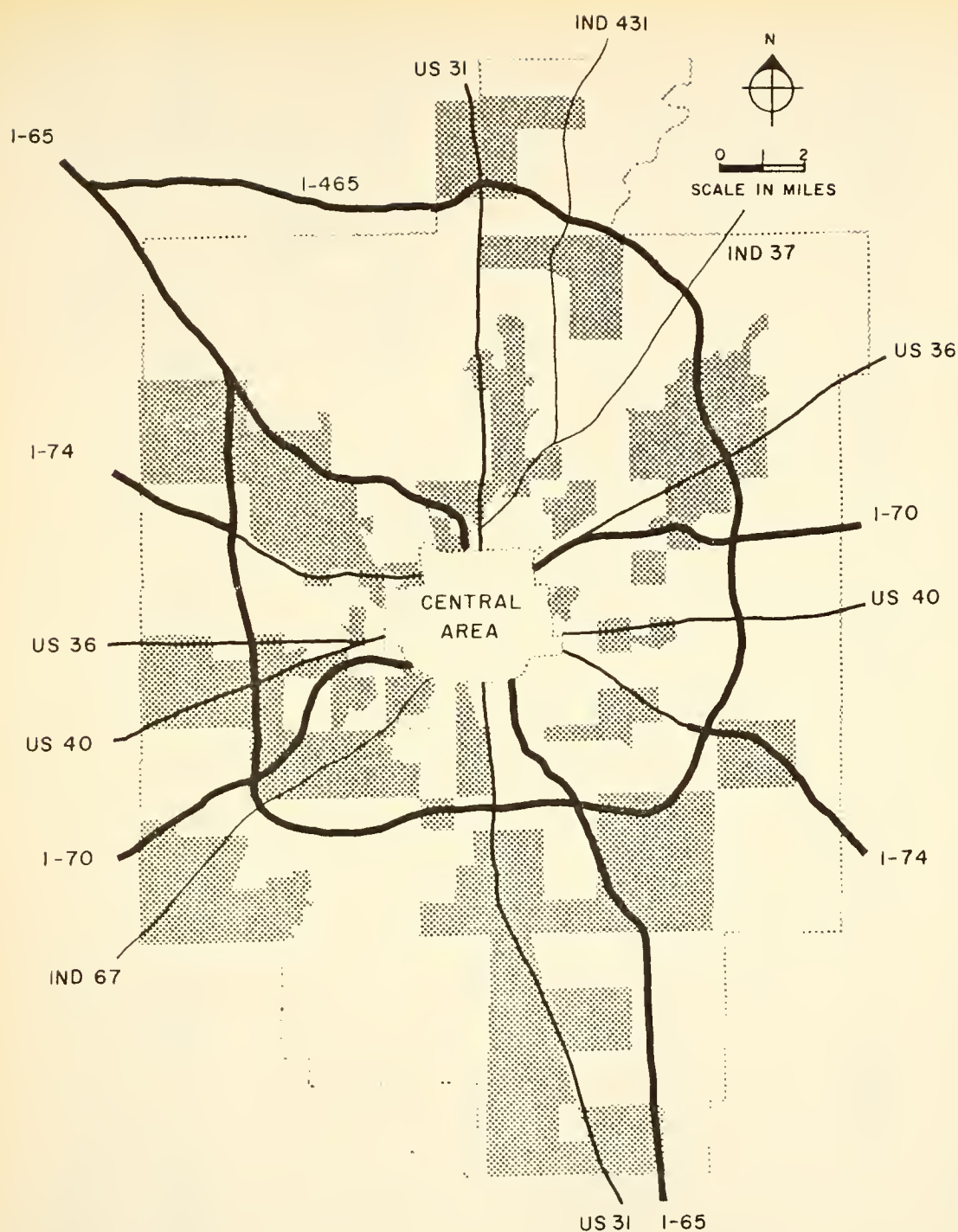


FIGURE 2 - NON CENTRAL AREA ZONES WHERE BASIC IRTADS MODELS DID NOT OVERFORECAST TRIPS FOR : NHBWKP, HBWKA, HBSHPA, AND / OR NHBWKA TRIP PURPOSES

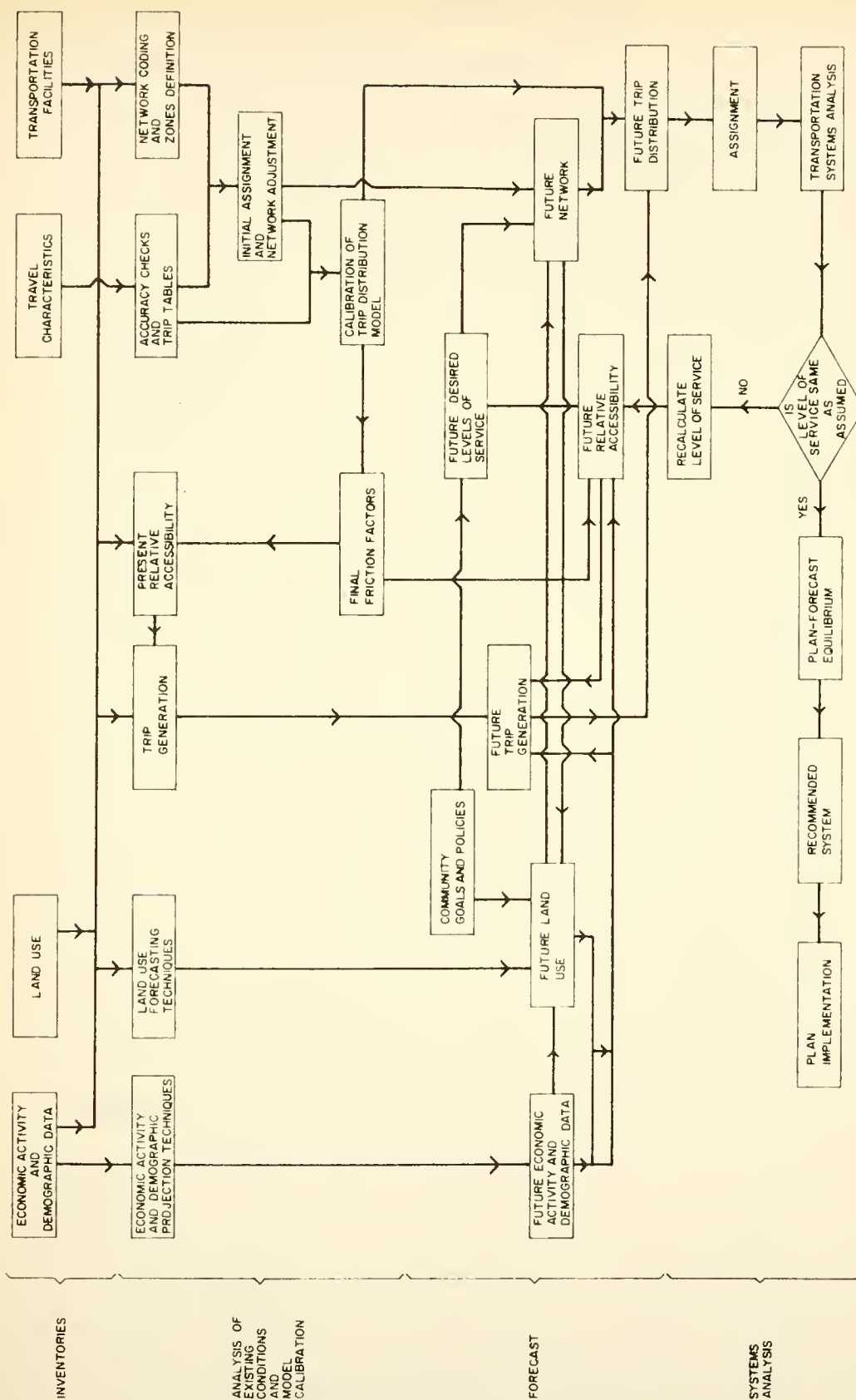


FIGURE 3 - THE PROPOSED TRIP GENERATION PROCESS

Alternate Planning Process for Small Cities

This research had three purposes:

1. Examine the presently recommended procedures for transportation planning to determine what simplifications might be made for small urban areas;
2. Develop the necessary simplified techniques;
3. Demonstrate the use of the simplified methodology in a small urban area.

The scope of the research here reported will cover the first two of the three purposes stated above. The third purpose is to be conducted as future research.

The need for a simplified planning process for small urban areas stems from two basic factors: (1) the relatively higher cost of the origin-destination survey, and (2) the difficulty of obtaining qualified personnel in sufficient numbers to perform the typical transportation planning study. The origin-destination survey as originally devised was needed to obtain the travel patterns into and within the study area. However, this may not be necessary in small urban areas.

Small cities have few major traffic generators. By thoroughly examining these generators, the street system, and the residential areas, one may be able to identify where, or if, travel patterns differ from traffic volumes. A major diversion of travel patterns may be caused by severe congestion along the most direct route or the absence of a direct route. A thorough analysis of the existing system with respect to the

requirements and standards for street systems should identify the presence of either of these causes.

Many of the major travel patterns are oriented toward the central business district (CBD). The CBD is probably by far the greatest trip attractor. Major travel corridors will radiate from the downtown toward major external routes. It is these centrally oriented corridors that usually are of the most importance. This relative importance is based on the fact that these corridors probably have the highest demand.

An estimate of the future demand is very necessary by corridor to determine the amount and type of facilities needed in each corridor. If the street system can handle these demands it can probably also handle the volumes in the outlying areas. Since the downtown is typically the largest traffic attractor, the traffic will usually be heaviest nearer this area.

An acceptable estimate of the future traffic in each corridor might be obtained by multiplying the existing traffic volumes by a growth factor. This factor could be based on the growth of all the "activities" in that corridor. By comparing these estimated future volumes to the available capacities of the streets, an estimate of the future deficiencies may be obtained.

The validity of applying growth factors directly to street volumes is predicated on the stability of the existing travel patterns. This is not a dangerous assumption in most small cities. The growth of these cities is generally represented

by a simple extension of the present patterns. If this is true, then the direct application of growth factors to present traffic volumes should be very valid and a procedure to do this was developed.

Initially, corridors which comprise one or more major streets serving essentially the same movement are identified. With a knowledge of local travel habits and the relative speeds and distances on the arterials, the boundaries of corridors can be set. For the most part the boundary will be equidistant from parallel arterials if these arterials are approximately equal to their attractiveness to the driver. Centrally-oriented corridors will, in general be more narrow near downtown and wider at the external cordon line. Other corridors may also be identified along cross routes and circumferential routes.

The traffic in many small cities may be composed of a high percentage of external-internal or external-external traffic. For this study, it is recommended that an external cordon interview survey still be conducted on major routes that cross the cordon line. For external-internal traffic, the location of the trip end within the study area would therefore be known. This traffic can thus be subtracted from the existing volumes on the streets and forecast separately. Likewise external-external traffic can be estimated separately.

An essential part of the proposed corridor method of forecasting internal travel patterns is the development of an appropriate growth factor for each corridor. This factor must represent all the activities in the corridor. Many corridors

contain dwelling units, employment centers and shopping areas as well as recreational facilities etc. All of these types of land uses have different trip generating characteristics. Therefore, it was necessary to weight the relative trip attractiveness of the various land uses.

A measurable parameter was needed to indicate each trip purpose. These parameters must be obtained easily for the present year by corridor and must be able to be projected to some future year. The corridor growth method requires land use forecasts that can provide future estimates of these parameters.

Three parameters were decided to be sufficient. Total employees were used for work trips, business trips and any other trips to places of employment. Retail employees were used for shopping trips and social-recreational trips to restaurants and taverns. Dwelling units were used for trips to home and other trips to residential areas. The percentage of total trips that was considered to be measured by each parameter is given as: total employees - 40 percent, retail employees - 15 percent, and dwelling units - 45 percent.

The exact percentages are, of course, not known. The above values are believed to be reasonable. A study of origin-destination study data from similar size cities should help determine what percentages should be used in any specific city.

The above percentages were used to establish relative trip production rates for the three parameters for this study. This was accomplished by determining the total quantity of

each parameter in the study area and then dividing the percentage by this total. The trip rate if the study area contained 20,000 employees would be $0.40/20,000$ or 2.0×10^{-5} . The 10^{-5} could be dropped for all parameters.

The procedure used in this research for developing a growth rate for each corridor using the relative trip rates was as follows:

1. Multiply the relative trip rates by the quantity of each appropriate parameter in the base year and add the three products.
2. Repeat Step 1 using the future quantities of the three parameters.
3. The ratio of the two sums is the growth factor for that corridor.

This investigation was concerned with reducing the cost and personnel requirements for major thoroughfare planning in small urban areas. A growth factor-corridor method for estimating future demand was developed and tested. Utilizing this method in the urban transportation planning process, it is believed future major deficiencies can be identified and realistic solutions developed. Although the methodology was tested in only one small urban area, the Greater Lafayette, Indiana, Urban Area, the findings may be applicable to many small urban areas.

Conclusions which are made are as follows:

1. The proposed growth factor-corridor method estimated future travel demands sufficiently accurately to indicate the

location and number of lanes of needed major improvements.

2. Three parameters were sufficient to indicate the growth of traffic volumes within a corridor. These parameters -- dwelling units, employees, and retail employees -- are easy to obtain for present conditions and to project into the future.

The use of the proposed growth factor-corridor method in the urban transportation planning process might provide the needed forecasts of future travel patterns required for the preparation of sound transportation plans. There are several conditions in small urban areas which indicate sound plans could thus be developed. Important among these conditions are the following:

1. Many traffic problems in small cities may be minimized through traffic engineering measures and physical improvements within the right-of-way of the existing arterial system.

2. Realistic locations for major improvements are severely restricted by the existing street network, external routes and urban development. Therefore, evaluation among any alternatives is greatly simplified.

3. Because the alternatives are limited and travel patterns are easily identified in the small city, a subjective consideration of the travel and other requirements for urban street systems will often lead immediately to the proper course of action.

The methodology developed in this research might prove adequate for sound recommendations for a realistic and adequate major thoroughfare plan for a small urban area. By eliminating

the origin-destination home interview study and the need for sophisticated trip distribution and traffic assignment techniques, great savings in time, cost and personnel requirements could be realized through the proposed simplified approach to major thoroughfare planning. A demonstration of the use of the proposed methodology is recommended in a small city in the near future.

Acknowledgements

The research parts summarized here were conducted by graduate research assistants namely, R. J. Hensen, G. A. Shunk, H. Ayad, T. Z. Nakkash and D. K. French, under the supervision of Professors H. L. Michael, J. C. Oppenlander and W. L. Grecco.

Reports Issued

1. "System Evaluation by the Simplified Proportional Assignment Technique," Joint Highway Research Project, Report No. 13, June 1967, Hassan Ayad.
2. "The Journey to Work: A Singular Basis for Travel Pattern Surveys," Joint Highway Research Project, Report No. 29, November 1967, G. A. Shunk.
3. "An Information Manual on the Urban Transportation Planning Process for Technical Committees in Smaller Urban Areas," Joint Highway Research Project, Report No. 19, September 1968, R. J. Hensen and W. L. Grecco.
4. "A Simplified Procedure for Major Thoroughfare Planning in Small Urban Areas," Joint Highway Research Project, Report No. 29, October 1968, D. K. French.
5. "Activity-Accessibility Models of Trip Generation," Joint Highway Research Project, Report No. 10, May 1969, Tammam Nakkash.

Appendix

Recommendations for Future Research

Part I - This research had a very limited objective: the development of an information manual. Its application requires only a distribution of the manual to members of the technical committees in the smaller urban areas. It may prove advantageous that persons from the district office of the Bureau of Public Roads, from the urban division of the State Highway Departments or from nearby universities cooperatively offer seminars to elucidate the manual.

Part II - Based on the preceding analyses and conclusions on work travel surveys, the following further study is recommended:

1. The regression coefficients of the prediction equations established for the IRTADS data should be tested on data from other urban areas. If no significant differences are found, the survey expansion procedure would be greatly simplified.
2. The representivity of the work trip for all purpose travel should be examined in different size urban areas in order to define the effect of size on representivity.
3. The surveys proposed in this research should be executed simultaneously with a traditional travel survey in order to define the relative strengths of each approach and to eliminate the criticism noted earlier, that the work trips examined in this research were actually drawn from a home-interview survey.

4. Further investigations should be made of the effect of characteristics of the place and type of employment on the observed relationships in order to improve the estimates of work trip generation. This seems appropriate because of the importance that work travel will assume in prediction of total urban travel.
5. Study should be made of the effect the number of employees in each work place has on the observed relationship in order to better define the extent of survey required.
6. A study should be made of the effect on prediction of total travel by using only those trips to major employment concentrations. These effects should be established for urban areas of varying size.
7. More detailed investigation should be made of the implications of various types of industrial and residential land use locations since this will become highly important in planning based on the procedure proposed here.

Part III - The Simplified Proportional Assignment Technique, which was formulated in this research investigation, covers several areas related to traffic engineering and transportation planning. Although it was developed to an operational stage in this study, further research is needed to refine certain phases of the assignment process. Future work should be concentrated on: community objectives, driver characteristics,

and computer programming. The following recommendations are noted as specific research activities which should assist in the application of SPAT in system evaluation.

1. The selected interzonal levels of service and qualities of traffic flow on a transportation system determine to a large degree the costs associated with an adopted plan that meets the study objectives. Research is warranted to determine the sensitivity of variations in these decision-making parameters on the development of transportation plans. Such work would guide in the selection of the proper values for these parameters and would establish the extent to which improved travel conditions for the road user justify additional expenditures.

2. The allocation of trip interchanges to alternate routes in the Simplified Proportional Assignment Technique is performed on a proportional basis that accounts for differences in travel time, route distance and tension experienced in driving the route. Further research is required to evaluate the relative importance of these factors, and, in particular, the exponent of each variable used in the proportioning of traffic to the alternate acceptable routes. The evaluation of these factors should account for differences in trip purpose and length.

3. The computer program developed in this research investigation is limited to the evaluation of transportation systems for medium-size communities. Because it was developed to demonstrate the validity of the SPAT concept, additional efforts in improving the efficiency of the computer program are needed to permit the evaluation of large urban transportation systems.

Part IV. The research on the activity accessibility models for trip generation resulted in the following recommendations for further work:

1. A study of the effects of changes in the transportation network level of service on the trip generation characteristics of an urban area should be conducted as soon as data for two points in time are available for medium and large size urban areas.
2. A test should be made to establish if the same relative accessibility variables identified by this investigation would be relevant to trip generation in other urban areas. The research should include urban areas with a range of sizes: larger and smaller than this study.
3. The sensitivity of the relationship of trip generation to relative accessibility variables should be investigated for different size urban areas, which would test the hypothesis that relative accessibility is a more important factor in larger urban areas.
4. For larger urban areas, the importance of non-highway transit accessibility as a factor in the trip generation models should be investigated.
5. Further research is needed to establish the criteria for differentiating the districts (or zones) between the central or noncentral strata.

6. Consideration should be given to the possibility of a three level stratification: the first level being the central or CBD area; the second level taking in those districts (or zones) which are noncentral and along major transportation corridors; and lastly, the remainder of the noncentral area. This research should provide knowledge on the effects on trip generation of different urban growth patterns and transportation systems.
7. When formulating relative accessibility variables to be included in models of auto-trip attractions, the consideration of the availability of parking at the destination end of the trip should be investigated.

Part V. This research has developed a simplified procedure of thoroughfare planning. One of the basic premises of this simplified planning process is that the development of alternatives and plan evaluation should be based on acceptable principles and standards of street systems. Furthermore, the existing system and land use development is so restrictive that few realistic courses of action exist. Thus, the evaluation of proposals is greatly simplified. This cannot be proved, only demonstrated.

To demonstrate this premise, all of the basic steps of thoroughfare planning must be conducted. This then is the next step in this research on simplified thoroughfare planning, a demonstration of its adequacy in a small city.

